Chronic Nonspecific Respiratory Disease in Berlin, New Hampshire, 1967 to 1973

A Further Follow-up Study[1, 2]

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SUMMARY

The 1967 sample of Berlin, New Hampshire was resurveyed in 1973 by means of a standard questionnaire on respiratory symptoms and by simple tests of pulmonary function. Measurements of the levels of air pollution showed a decrease in the number of suspended particulates and an increase in the concentration of sulfation. These values were close to the Federal Primary Standard. No differences in respiratory symptoms, prevalences of chronic, nonspecific respiratory disease, or pulmonary function were detected. Within the limitations of this study, we concluded that the Federal Primary Standards for sulfur dioxide and total suspended particulates are probably adequate to protect the public.

Introduction

National ambient air quality standards for sulfur dioxide (SO_2) and particulates have been in effect for a number of years. They were developed on the evidence available at that time (1, 2). It was recognized that over the years, these levels should be verified to determine whether or not they were adequate. Our long-term studies in Berlin, N. H. have provided a means of verifying the original standards and trying to determine the relative importance of SO_2 versus the particulates. At present, no standard exists for sulfates. It is possible to analyze for sulfates, but it is much more difficult to identify the type of sulfate, which may be most important in assessing health effects.

Our studies in Berlin, N. H. have been designed as longitudinal or prospective studies. Such studies are probably better than repeated cross-sectional studies, because the surviving population can serve as its own control group. Such studies suffer from attrition of the population (emigration and death) and require continuity of personnel and comparability of methods in their execution. These studies follow the survivors, who may comprise the healthier segment of the original population. Comparisons of cross-sectional studies in different localities always raise the question of whether cultural, racial, or social differences could have influenced the results. For these reasons, we have done a second follow-up study on our Berlin population. This report is concerned with the 6-year follow-up of the 1967 sample. That sample consisted of a group selected in 1961 (3) and an additional group selected in 1967 (4). Our purpose was to see whether the changes in the levels of air pollution were affecting health and to compare the results with the previous 6-year follow-up study (5).

Materials and Methods

The levels of air pollution were monitored in 1966 to 1967 and have been reported previously (6). Levels of exposure in 1961 were obtained from a U. S.

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Public Health Service survey made at that time (7). Since 1967, the city and the state have continued measurements of the sulfation rate on a monthly basis and high-volume sampling on a random basis during each month. These results have been made available to us. Since 1973, we have been taking air samples for measurement of other pollutants for varying periods during a week, 2 to 4 times per year by means of a portable sampling device (8). Other pollutants measured were SO_2, nitrogen dioxide (NO_2), CO, mass respirable particulates, lead, and high-volume samples to determine whether these pollutants were present at concentrations at which they could be suspected to be factors in the production of respiratory disease. Sampling sites were similar at the different sampling periods.

The population surveyed in the cross-sectional study of 1967 (4) was re-examined using the same standardized questionnaire that had been used to record respiratory symptoms, chest illnesses, occupational histories, and smoking habits.

Five observers administered the questionnaire and the tests of pulmonary function; two were physicians, and the others were trained interviewers. Virtually all of the home visits were done by one interviewer (BF). Home interviews represented 30.3 per cent; BF interviewed a total of 45.7 per cent; SP, 24.0; HC, 25.1 per cent; RLHM, 1.2 per cent, and DH, 3.8 per cent. Subjects seen at home had more symptoms and slightly lower pulmonary function than those seen in the central interviewing facility. This comparison was made for subjects seen by the same observer (BF), and the difference persisted even when results from all interviewers were included. Thus, a group of persons who were sicker than average was detected by home visits in this survey.

Pulmonary function was measured by means of Stead-Wells spirometers. Survey Stead-Wells spirometers were used for home visits in 1973. The table-top model had been used for home visits in 1967. Both types were used at the central interviewing station in 1973. The various spirometers used were calibrated against each other and under conditions of use. Their agreement and accuracy were within 1 per cent. As in previous studies, 5 trials were made, and the average of the last 3 acceptable efforts was used. Expiration was continued for 6 or more sec. The forced vital capacity (FVC) and 1-sec forced expiratory volume (FEV_1) were obtained from the tracings. Paper speed was 3.2 cm per sec. The values were corrected to body temperature and pressure, saturated with water vapor. Peak expiratory flows were measured by means of Wright peak flow meters that had been calibrated with a standard orifice meter under conditions of use. The values obtained were corrected according to the appropriate calibration curve, and results were obtained at ambient temperature and pressure. Five trials were performed, and the average of the last 3 acceptable trials was used.

All measurements were done with the subject seated and without a nose clip.

Chronic, nonspecific respiratory disease was diagnosed as follows, with the categories not considered mutually exclusive: (*1*) chronic bronchitis, if production of phlegm had occurred for 3 consecutive months or more each year for the past 3 years; (*2*) asthma, if a doctor had diagnosed asthma and it was still present; (*3*) chronic obstructive pulmonary disease, if any one or a combination of the following was present—wheezing or whistling in the chest most days or nights, the subject had to stop for breath when walking at his own pace on the level, FEV_1 was less than 60 per cent of FVC.

Results and Discussion

Air pollution levels. The levels of air pollution, as measured by sulfation rate and high-volume sampling, are presented in table 1 for the period 1961 to 1973. The concentration of suspended particulates has progressively decreased as a result of the conversion from coal to oil in the power plants of the mill, the replacement of the sulfite process of manufacturing pulp by the Kraft process, and the institution of some con-

TABLE 1

LEVELS OF AIR POLLUTION, BERLIN, NEW HAMPSHIRE, 1961 TO 1973

	1961	1966–67	1973	Primary Standard
Sulfation*, μg of SO_3/100 cm^2/day	731 ± 241	469 ± 111	901 ± 287	
SO_2 equivalents†, ppb	21 ± 7	14 ± 3	25 ± 8	
Measured SO_2, ppb	–	2** ± 1	10†† ± 6.5	30
Total suspended particulates, $\mu g/m^3$***	180 ± 71	131 ± 82	80 ± 62	75
Mass respirable particles, $\mu g/m^3$†††	–	–	34 ± 22	

*Monthly data from lead peroxide candles or plates.

†Assumes constant conditions and that conversion can be calculated by: Sulfation, in μg per 100 cm^2 per d/35.5 = SO_2 in ppb.

**By hydrogen peroxide method; 24-hour values were compiled monthly.

††By West-Gaeke method; 8-hour values were compiled for selected weeks.

***High-volume samplers; 24-hour values were compiled monthly.

†††Cyclone used to remove particles > 3.5 μm; 8-hour values were compiled for selected weeks.

TABLE 2

STATUS IN 1973 OF MEN STUDIED IN 1967, BERLIN, NEW HAMPSHIRE

Age in 1967 (years)	Original Sample (no.)	Dead (no.)	Moved (no.)	Work Out of Town (no.)	Too Ill (no.)	Missed (no.)	Refused (no.)	Inter-viewed (no.)	Interviewed/ Available* X 100 (%)
< 25	10	–	2 (20.0)†	–	–	1 (10.0)	–	7 (70.0)	87.5
25–34	61	–	11 (18.0)	–	–	–	–	50 (82.0)	100.0
35–44	165	3 (1.8)	13 (7.9)	–	–	–	6 (3.6)	143 (86.7)	96.0
45–54	146	13 (8.9)	5 (3.4)	1 (0.7)	2 (1.4)	1 (0.7)	7 (4.8)	117 (80.1)	93.6
55–64	150	32 (21.3)	10 (6.7)	–	1 (0.7)	2 (1.3)	6 (4.0)	99 (66.0)	92.5
65–74	163	56 (34.4)	6 (3.7)	–	1 (0.6)	–	5 (3.1)	95 (58.3)	95.0
75+	26	13 (50.0)	–	–	1 (3.8)	–	2 (7.7)	10 (38.5)	83.3
Total	721	117 (16.2)	47 (6.5)	1 (0.1)	5 (0.7)	4 (0.6)	26 (3.6)	521 (72.3)	94.6

*Available = subjects interviewed plus those who refused or were missed.
†Numbers in parentheses are percentages of original sample from 1967.

trol processes. The fluctuations in the sulfation rate reflect the abandonment of the sulfite process in 1963, followed by a doubling to tripling of the Kraft production. Thus, from 1967 to 1973, there was an increase in the sulfation rate but a continued decrease in the concentration of particulates. Because the high-volume sampler can collect nonrespirable particles (greater than 10 μm), this reduction in mass could reflect the elimination of these larger particles; however, we do not have data on the particle size distribution in Berlin in the past. As of 1973 to 1974, the mass respirable fraction made up 43 per cent, by weight, of the total amount of suspended particulates.

Of further interest are the concentrations of sulfur compounds. If all of the sulfation measurement were due to SO_2 this would have required concentrations in the range given under SO_2 equivalents (table 1); these were calculated as indicated in the footnote to that table. When we compared these values with those actually measured, there was a wide discrepancy, because the measured concentrations of SO_2 were much lower than the SO_2 equivalents. Some of this discrepancy might be due to differences in methodology. On the other hand, a variety of other sulfur compounds is present in the air, including sodium sulfate, possibly other sulfates, hydrogen sulfide, and mercaptans or other organic sulfides. Again, we do not have a complete breakdown of these constituents. It is relevant that SO_2 values are low, and even if all of the sulfation were due to SO_2, the concentration would be less than the primary standard promulgated in the Federal register (80 μg per m^3; 0.03 ppm).

Spot measurements of other pollutants showed 1 to 5 ppm of CO (1.15 to 5.75 μg per m^3) for hourly values, < 0.01 ppm of NO_2 (18.8 μg per m^3) from 4- to 8-hour samples, 0.6 to 0 μg of lead per m^3, and a mean of 34 μg of mass respirable particles (range: 80 to 20 μg per m^3). These are the average values for 4- to 8-

TABLE 3

STATUS IN 1973 OF THE WOMEN STUDIED IN 1967, BERLIN, NEW HAMPSHIRE

Age in 1967 (years)	Original Sample (no.)	Dead (no.)	Moved (no.)	Work Out of Town (no.)	Too Ill (no.)	Missed (no.)	Refused (no.)	Inter-viewed (no.)	Interviewed/ Available* X 100 (%)
< 25	13	–	2 (15.4)†	–	–	–	1 (7.7)	10 (76.9)	90.9
25–34	92	–	11 (12.0)	–	–	–	4 (4.3)	77 (83.7)	95.1
35–44	179	4 (2.2)	13 (7.3)	–	–	1 (0.6)	5 (2.8)	156 (87.2)	96.3
45–54	202	7 (3.5)	14 (6.9)	1 (0.5)	1 (0.5)	1 (0.5)	11 (5.4)	167 (82.7)	93.3
55–64	175	10 (5.7)	10 (5.7)	3 (1.7)	–	1 (0.6)	16 (9.1)	135 (77.1)	88.8
65–74	184	31 (16.8)	15 (8.2)	1 (0.5)	3 (1.6)	–	9 (4.9)	125 (67.9)	93.3
75+	22	7 (31.8)	2 (9.1)	–	–	1 (4.5)	2 (9.1)	10 (45.5)	76.9
Total	867	59 (6.8)	67 (7.7)	5 (0.6)	4 (0.5)	4 (0.5)	48 (5.5)	680 (78.4)	92.9

*Available = subjects interviewed plus those who refused or were missed.
†Numbers in parentheses are percentages of original sample from 1967.

TABLE 4

AGE-STANDARDIZED RATIOS (RATES) OF SELECTED RESPIRATORY SYMPTOMS IN MEN IN 1967 AND 1973, BY 1973 CIGARETTE SMOKING CATEGORY

1973 Cigarette Smoking Category (cigarettes/day)	Cough		Phlegm		Cough and Phlegm		Wheezing		Shortness of Breath 2+*		Shortness of Breath 3+†		Total
	1967	1973	1967	1973	1967	1973	1967	1973	1967	1973	1967	1973	
Never smoked	0.29 (6.0)**	0.4 (8.5	0.40 (8.9)	0.34 (7.6)	0.35 (5.1)	0.25 (3.7)	0.24 (2.0)	0.12 (1.0)	0.64 (5.2)	1.01 (8.2)	0.33 (1.0)	0.49 (1.6)	104
Ex-smoker	0.99 (20.5)	0.4 (9.7	1.04 (23.3)	0.71 (15.9)	0.96 (14.1)	0.42 (6.2)	0.80 (6.5)	0.58 (4.7)	0.49 (4.0)	0.96 (7.8)	0.65 (2.1)	0.93 (2.9)	211
1–14	1.07 (22.2)	1.2 (25.5	0.80 (17.9)	1.23 (27.5)	1.11 (16.3)	1.33 (19.5)	0.26 (2.1)	1.04 (8.5)	0.73 (6.0)	1.52 (12.4)	1.23 (3.9)	1.77 (5.6)	49
15–24	1.71 (35.4)	1.2 (26.5	1.42 (31.8)	1.34 (30.0)	1.94 (28.5)	1.24 (18.2)	2.27 (18.5)	2.26 (18.4)	1.38 (11.3)	1.03 (8.4)	0.80 (2.5)	2.67 (8.5)	59
25–34	1.26 (26.1)	1.2 (25.7	1.51 (33.8)	1.45 (32.4)	1.46 (21.4)	1.24 (18.2)	0.84 (6.9)	1.65 (13.5)	3.13 (25.5)	1.33 (10.8)	1.43 (4.5)	0.94 (3.0)	43
35+	2.44 (50.6)	2.7 (56.4	1.66 (37.1)	2.32 (51.9)	2.36 (34.7)	2.90 (42.6)	3.14 (25.6)	1.75 (14.3)	0.68 (6.5)	2.05 (16.7)	2.15 (6.8)	1.39 (4.4)	55
												Total No.	521

*Shortness of breath causing the person to walk slower on the level than persons of same age.

†Shortness of breath when walking at one's own pace on the level.

**Values in parentheses are the age-standardized rates.

TABLE 5

AGE-STANDARDIZED RATIOS (RATES) OF SELECTED RESPIRATORY SYMPTOMS IN WOMEN IN 1967 AND 1973, BY 1973 CIGARETTE SMOKING CATEGORY

1973 Cigarette Smoking Category *(cigarettes/day)*	Cough		Phlegm		Cough and Phlegm		Wheezing		Shortness of Breath 2+*		Shortness of Breath 3+†		Total
	1967	1973	1967	1973	1967	1973	1967	1973	1967	1973	1967	1973	
Never smoked	0.48 (4.4)	0.67 (6.2)	0.72 (8.1)	0.66 (7.4)	0.61 (3.6)	0.38 (2.2)	0.62 (2.5)	0.55 (2.2)	0.92 (14.1)	0.94 (14.4)	0.87 (4.5)	0.93 (4.9)	364
Ex-smoker	0.35 (3.2)	0.56 (5.2)	0.65 (7.3)	0.90 (10.1)	0.36 (2.1)	0.34 (2.0)	2.02 (8.0)	0.78 (3.1)	0.77 (11.8)	0.98 (15.0)	1.27 (6.6)	0.84 (4.4)	94
1–14	1.15 (10.7)	1.08 (10.0)	1.03 (11.6)	0.87 (9.8)	1.35 (7.9)	1.05 (6.2)	0.31 (1.2)	0.29 (1.2)	0.66 (10.1)	0.67 (10.2)	0.30 (1.6)	0.73 (3.8)	80
15–24	2.10 (19.5)	1.76 (16.3)	1.94 (21.8)	0.87 (9.8)	2.44 (14.4)	0.92 (5.4)	2.61 (10.4)	0.58 (2.3)	1.23 (18.8)	1.03 (1.58)	1.85 (9.7)	0.76 (4.0)	87
25–34	2.94 (27.2)	1.74 (16.1)	2.00 (22.5)	1.94 (21.8)	3.38 (19.9)	2.12 (12.5)	0.82 (3.3)	3.14 (12.5)	1.74 (26.6)	2.25 (34.4)	2.42 (12.6)	2.06 (10.8)	30
35+	4.83 (44.7)	3.35 (31.0)	3.83 (43.1)	3.66 (41.2)	6.86 (40.4)	4.50 (26.5)	9.08 (36.1)	1.93 (7.7)	1.51 (23.1)	2.59 (39.6)	2.11 (11.0)	1.85 (9.7)	25
												Total No.	680

*Shortness of breath causing a person to walk slower than persons of same age on the level.

†Shortness of breath when walking at one's own pace on the level.

**Values in parentheses are the age-standardized rates.

hour periods of sampling. All of the values are low, so that these substances are probably not having any significant effect on the health of the population.

Health effects. The possible effects on health of changes in the levels of pollution were assessed using the data in tables 2 and 3, which show what happened to the 1967 sample by 1973. The mortality was 2.5 times greater for men than women, but the other reasons for loss to follow-up were similar for men and women. These changes were also similar to those seen in the 1967 follow-up of the 1961 sample (5), except that the percentage of the population that moved was one-half as great in 1973. Age-standardized mortality rates were the same for 1961 to 1967 and 1967 to 1973 for both men and women. Response rates were slightly lower in 1973 than 1967, primarily as a result of the missed persons, but the response rates were still adequate.

It is inevitable that we are following a survivor population. In an earlier report (9), we noted that the persons who moved away had had symptom prevalences and pulmonary function values similar to those of persons whom we later interviewed. Those who died, however, had had more symptoms and poorer pulmonary function in the earlier study. Thus, in 1973, we studied a survivor population that probably was not biased by those who had moved away, but did represent the healthier portion of the population.

Crude prevalences of selected symptoms showed patterns similar to those seen previously. Only persons interviewed at both times were

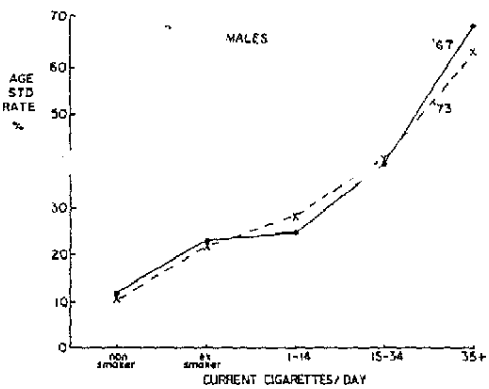

Fig. 1. Relationship of age-standardized (AGE STD) prevalences of chronic, nonspecific respiratory disease in men, by cigarette smoking category, from two studies, 1967 and 1973, in Berlin, New Hampshire.

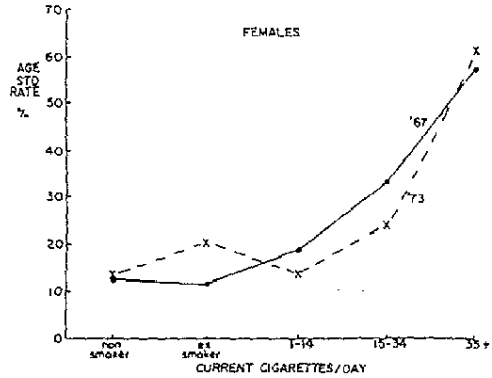

Fig. 2. Relationship of age-standardized (AGE STD) prevalences of chronic, nonspecific respiratory disease in women, by cigarette smoking category, from two studies, 1967 and 1973, in Berlin, New Hampshire.

included in these and other tables. For example, men continued to give up cigarette smoking; women were still taking it up, but not as much as in 1967. These crude prevalences have limited usefulness because of the effects of aging and changes in smoking habits. The crude prevalences, therefore, were age-standardized to the combined population of 1967 and 1973 and presented as ratios and rates by current (1973) cigarette smoking category for men (table 4) and women (table 5). As noted in the earlier follow-up study (5), no consistent trends were apparent. The number of cells that showed a decrease in disease rates was approximately the same as the number that showed an increase. When we look for an effect of air pollution, we must compare the results within a given cell, because in that cell corrections have been made for cigarette smoking and age. For virtually all of the symptoms, for men and women, there was an increase in prevalence with increased cigarette smoking. There were occasional discrepancies that probably reflected the small [illegible] in that particular cell.

This inability to show much difference in the prevalence of symptoms at these relatively low levels of air pollution may reflect the insensitivity of the individual symptoms at measuring an effect. Therefore, we used clusters of symptoms to make diagnoses of chronic, nonspecific respiratory disease, as defined in Materials and Methods. The prevalences of the diagnoses were then examined for persons seen by the same observer (BF) during the two surveys. In contrast to the 1961 to 1967 comparison (5), the difference be-

RESP

AGE-STANDARDIZED
IN MEN, BY CIGARETT

Cigarette Smoking Category (cigarettes/day)	1967	1
Never smoked		
Ex-smoker		
1–24		
25+		

*Number in parentheses ir

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AGE-STANDARI
IN WOMEN, BY CIG

Cigarette Smoking Category (cigarettes/day)	
Never smoked	
Ex-smoker	
1–24	
25+	

*Number in paren

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TABLE 6

AGE-STANDARDIZED RATES FOR ALL CHRONIC NONSPECIFIC RESPIRATORY DISEASE IN MEN, BY CIGARETTE SMOKING CATEGORY IN 1967 AND 1973, BERLIN, NEW HAMPSHIRE

Cigarette Smoking Category (cigarettes/day)	1967 \ 1973	Never Smoked		Ex-Smoker		1–24		25+	
		1967	1973	1967	1973	1967	1973	1967	1973
Never smoked		13.1 (104)*	11.0	0 (10)	0	0 (1)	80.0		
Ex-smoker				23.5 (123)	23.8	14.3 (7)	14.0	30.0 (4)	26.2
1–24				31.2 (60)	19.3	33.0 (77)	33.6	47.6 (21)	60.7
25+				70.5 (18)	33.9	53.3 (23)	64.0	51.5 (73)	52.7

*Number in parentheses indicates number in that cell.

tween 1967 and 1973 was in the opposite direction, namely, more positive diagnoses were made in 1973. This probably reflects the large number of persons seen at home by this observer. When data from all observers were pooled, as in figures 1 and 2 for men and women, no differences were noted. Age standardization was done by the indirect method, after combining the two populations as described.

These ratios and rates were obtained by indirect standardization, by using the age-specific rates from the combined interviewed populations (1967 and 1973), all smoking categories together, as the standard ratio. Each age-specific rate was applied to the number of persons of the corresponding age group within each smoking category to provide an expected number of diseased persons. Within each smoking category, the numbers for all ages were added for each of the two years to obtain the total expected number for that category for that year. The ratio, then, is the ratio of the observed number to the expected number. The indirect age-standardized rate was then obtained from the following relationship.

$$\text{Age-standardized rate for smoking category for that year} = \frac{\text{Observed}}{\text{Expected}} \times \text{Crude rate for the total population together (two years combined)}$$

To control for the possible effects of changing cigarette smoking habits, the age-standardized ratios for all chronic, nonspecific respiratory disease were compared for the two surveys for men (table 6) and for women (table 7). The heavily outlined values represent data for groups of subjects who were in the same cigarette smoking category at both surveys; any effect of air pollution should be sought within these categories, because there was no change in cigarette smoking habits, and age was taken into account.

TABLE 7

AGE-STANDARDIZED RATES FOR ALL CHRONIC NONSPECIFIC RESPIRATORY DISEASE IN WOMEN, BY CIGARETTE SMOKING CATEGORY IN 1967 AND 1973, BERLIN, NEW HAMPSHIRE

Cigarette Smoking Category (cigarettes/day)	1967 \ 1973	Never Smoked		Ex-Smoker		1–24		25+	
		1967	1973	1967	1973	1967	1973	1967	1973
Never smoked		12.6 (364)*	13.7	21.5 (5)	20.1	1.26 (6)	0		
Ex-smoker				10.4 (51)	27.2	18.6 (12)	17.1	0 (1)	118.2
1–24				18.8 (34)	8.9	24.1 (131)	17.7	36.5 (18)	39.9
25-				81.1 (4)	25.3	42.1 (18)	22.4	46.5 (36)	47.4

*Number in parentheses indicates number in that cell.

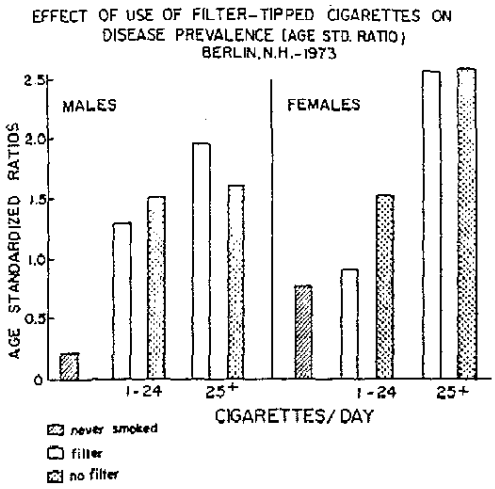

Fig. 3. Relationship of chronic, nonspecific respiratory disease prevalence to use of filter-tipped cigarettes in men and women; AGE STD = age-standardized.

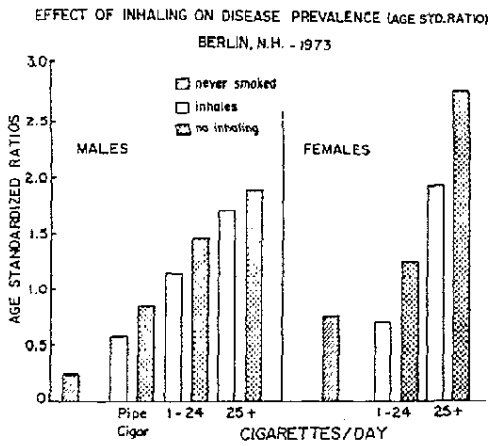

Fig. 4. Relationship of chronic, nonspecific respiratory disease prevalence to inhaling habits in men and women; AGE STD = age-standardized.

Again, there was no consistent difference between the 1967 and 1973 surveys. Those who reduced their smoking, however, tended to have a reduction in disease, and those who increased their smoking tended to have more disease.

An examination of the effects of the use of filter-tipped cigarettes and inhaling on respiratory symptoms showed results similar to those reported previously (4) (figures 3 and 4), namely, that the use of filter-tipped cigarettes did not seem to be a factor in reducing chronic, nonspecific respiratory disease, whereas inhalation of the smoke was a factor in producing more disease. There was some degree of consistency in the effects of inhaling, because the light inhalers had disease prevalences similar to those of the heavy inhalers in a lower smoking category.

Attack and remission rates for a selected cluster of respiratory symptoms are shown in table

TABLE 8

ATTACK AND REMISSION RATES FOR SELECTED RESPIRATORY SYMPTOMS (RS)* BY CIGARETTE SMOKING, 1973

1973 Cigarette Smoking *(cigarettes/day)*	Without RS in 1967 *(no.)*	Developed RS in 1973 *(no.)*	Attack Rate *(%)*	With RS in 1967 *(no.)*	Relieved of RS in 1973 *(no.)*	Remission Rate *(%)*
Men						
Never smoked	94	7	7.4	10	8	80.0
Ex-smoker	156	18	11.5	55	30	54.5
1–14	39	8	20.5	10	1	10.0
15–24	38	6	15.8	21	6	28.6
25–34	28	9	32.1	15	8	53.3
[illegible]	[illegible]			[illegible]	[illegible]	[illegible]
Total	384	60	15.6	137	57	41.6
Women						
Never smoked	320	28	8.8	44	23	52.3
Ex-smoker	80	11	13.8	14	10	71.4
1–14	69	7	10.1	11	8	72.7
15–24	62	4	6.5	25	17	68.0
25–34	22	7	31.8	8	5	62.5
35+	12	4	33.3	13	4	30.8
Total	565	61	10.8	115	67	58.3

*RS = chronic phlegm production, wheezing in chest most days or nights, and shortness of breath grade 3-plus, i.e., having to stop for breath when walking at one's own pace on the level.

TABLE 9

FORCED VITAL CAPACITY (FVC), ADJUSTED FOR AGE AND HEIGHT,* IN MEN; BY SMOKING CATEGORIES, BERLIN, NEW HAMPSHIRE, 1967 AND 1973

Cigarette Smoking Category (cigarettes/day)	1967 \ 1973	Never Smoked		Ex-Smoker		1–24		25+		Total	
		1967	1973	1967	1973	1967	1973	1967	1973	1967	1973
Never smoked		(100)† 3.78	3.84	(10) 3.69	3.83	(1) 3.69	3.86			(111) 3.77	3.84
Ex-smoker				(118) 3.77	3.86	(6) 4.16	3.99	(4) 3.37	3.61	(128) 3.78	3.86
1–24				(58) 3.78	3.78	(74) 3.80	3.80	(21) 3.62	3.67	(153) 3.77	3.77
25+				(18) 3.48	3.55	(22) 3.62	3.45	(72) 3.51	3.52	(112) 3.53	3.51
Total		(100) 3.78	3.84	(204) 3.74	3.81	(103) 3.78	3.74	(97) 3.53	3.55	(504) 3.72	3.75

*FVC (age-, height-adjusted) = observed FVC + 0.0382 (age − 53) + 0.0422 (170 − height).
†Number in parentheses indicates number in that cell.

8 for men and women, by cigarette smoking category in 1973.

As reported previously (5), attack rates increased with increasing cigarette smoking, and remission rates tended to decrease. These rates and those reported earlier are remarkably similar. The results in the men are consistent with those reported by Sharp and associates (10).

The results of the simple tests of pulmonary function are shown in tables 9 through 12. These

TABLE 10

FORCED EXPIRATORY VOLUME IN 1 SEC (FEV_1), ADJUSTED FOR AGE AND HEIGHT,* IN MEN, BY SMOKING CATEGORIES, BERLIN, NEW HAMPSHIRE, 1967 AND 1973

Cigarette Smoking Category (cigarettes/day)	1967 \ 1973	Never Smoked		Ex-Smoker		1–24		25+		Total	
		1967	1973	1967	1973	1967	1973	1967	1973	1967	1973
Never smoked		(100)† 3.05	3.11	(10) 2.97	3.01	(1) 3.12	3.37			(111) 3.04	3.10
Ex-smoker				(118) 2.97	3.01	(6) 3.13	2.92	(4) 2.64	2.86	(128) 2.97	3.00
1–24				(58) 2.91	2.93	(74) 2.87	2.87	(21) 2.73	2.69	(153) 2.87	2.87
25+				(18) 2.64	2.66	(22) 2.53	2.41	(72) 2.64	2.60	(112) 2.62	2.57
Total		(100) 3.05	3.11	(204) 2.92	2.95	(103) 2.82	2.78	(97) 2.56	2.63	(504) 2.88	2.89

*FEV_1 (age-, height-adjusted) = observed FEV_1 + 0.0386 (age − 53) + 0.0282 (170 − height).
†Number in parentheses indicates number in that cell.

values were standardized to a specified height and age, as noted in the tables. The regression equations used are given as footnotes to the tables and were based on the 1967 results. Data are given by the current cigarette smoking category in each year. The heavily outlined values represent data for groups of subjects who stayed in the same current cigarette smoking habits at the two surveys. No consistent pattern emerged. Similar results were obtained for each of the tests of pulmonary function. Thus, it would appear that these tests do not show any effect that can be associated with air pollution. There was, however, a small, but consistent, effect of cigarette smoking. Again, comparisons must be made among those who did not change their smoking habits. The number of subjects who changed their smoking habits was relatively small, so that it was not possible to draw specific conclusions. Those who became ex-smokers tended to show some improvement.

The question can be raised as to how relevant the air pollution measurements from a Kraft mill community are to other communities or to the Federal Air Quality standard. In all honesty, we do not know the answer.

Much of this uncertainty results from the standard not specifying the chemical composition of the particulates, but the implication is that the particulates are the result of burning fossil fuels. Also, the composition of the particulates in other communities is not known. In the earlier studies, the air pollution was probably more representative, because more SO_2 was emitted and also because of emissions from the coal-burning power plant. We do not know the composition of the particulates in Berlin, N. H., but some preliminary analyses by electronic spectroscopy for chemical analysis (ESCA) (conducted by Prof. D. Hercules, Athens, Ga.) have shown considerable amounts of sulfate in the particulates. The exact type has not yet been identified. We are in the process of trying to identify the specific sulfate, because the type of sulfate, i.e., sulfuric acid or sodium sulfate, makes a great difference in the effect on health. Until we have characterized the particulates in a variety of communities, we shall not know how representative or relevant the data of Berlin are to other communities.

Based on these observations, we concluded that either the changes in the levels of air pollution in Berlin, N. H. from 1967 to 1973 are not associated with a beneficial effect on health, or our methods of assessing an effect are not sufficiently sensitive at these levels. If our methods are adequate, and to the extent that the pollution in Berlin, N. H. is representative of urban air pollution, we conclude that the present federal standards for SO_2 and particulates are ade-

TABLE 11

FORCED VITAL CAPACITY (FVC), ADJUSTED FOR AGE AND HEIGHT,* IN WOMEN, BY SMOKING CATEGORY, BERLIN, NEW HAMPSHIRE, 1967 AND 1973

Cigarette Smoking Category (cigarettes/day)	1973 / 1967	Never Smoked		Ex-Smoker		1–24		25+		Total	
		1967	1973	1967	1973	1967	1973	1967	1973	1967	1973
Never smoked		2.63 (349)†	2.73	2.37 (5)	2.42	2.71 (6)	2.86			2.63 (360)	2.72
Ex-smoker				2.62 (46)	2.69	2.73 (12)	2.67	2.58 (1)	2.63	2.64 (59)	2.69
1–24				2.65 (33)	2.76	2.60 (126)	2.65	2.54 (17)	2.54	2.60 (176)	2.66
25+				2.51 (4)	2.82	2.41 (18)	2.31	2.46 (35)	2.48	2.45 (57)	2.45
Total		2.63 (349)	2.73	2.61 (88)	2.71	2.59 (162)	2.62	2.49 (53)	2.50	2.61 (652)	2.68

*FVC (age-, height-adjusted) = observed FVC + 0.280 (age − 52) + 0.321 (157 − height).
†Number in parentheses indicates number in that cell.

TABLE 12

FORCED EXPIRATORY VOLUME IN 1 SEC (FEV_1) ADJUSTED FOR AGE AND HEIGHT,* IN WOMEN, BY SMOKING CATEGORY, BERLIN, NEW HAMPSHIRE, 1967 AND 1973

Cigarette Smoking Category (cigarettes/day)	1973 / 1967	Never Smoked		Ex-Smoker		1–24		25+		Total	
		1967	1973	1967	1973	1967	1973	1967	1973	1967	1973
Never smoked		(349)† 2.22	2.27	(5) 2.04	2.04	(6) 2.36	2.37			(360) 2.22	2.27
Ex-smoker				(46) 2.23	2.23	(12) 2.23	2.17	(1) 1.93	2.17	(59) 2.22	2.22
1–24				(33) 2.16	2.25	(126) 2.12	2.11	(17) 2.03	1.99	(176) 2.12	2.12
25+				(4) 2.08	2.33	(18) 1.80	1.74	(35) 1.94	1.93	(57) 1.91	1.90
Total		(349) 2.22	2.27	(88) 2.19	2.23	(162) 2.10	2.08	(53) 1.97	1.95	(652) 2.16	2.19

*FEV_1 (age-, height-adjusted) = observed FEV_1 + 0.0264 (age − 52) + 0.0233 (157 − height).
†Number in parentheses indicates number in that cell.

quate to protect the public with some margin of safety.

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